Mineral waste in the UK

Innovation, optimisation and recycling

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British Geological Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

Outline of presentation

- Minerals at the British Geological Survey
- What is Mineral Waste?
- Quarry Fines
- Minimisation and utilisation
- Conclusions

British Geological Survey

- National geo-survey for the UK focusing on Public National Good science and geological research.
- Our understanding of the subsurface helps society
    - Use its natural resources responsibly
    - Manage environmental change
    - Be resilient to environmental change
- Over 500 scientists working with other 40 universities & institutes
- More information: www.bgs.ac.uk

BGS Minerals and me

Clive at a silica sand quarry in Hampshire, UK
http://www.bgs.ac.uk/staff/profiles/1159.html

- BGS compiles mineral statistics for UK, Europe and World
- Provides spatial mineral resource information
- Carries out research (metallogenesis, impacts of mineral extraction & resource security)
- BGS minerals information available as FREE downloads via www.mineralsUK.com
- Clive is an industrial Minerals Specialist, 27 years at the BGS, travelled far and wide for mineral evaluation, and based at the HQ of the BGS in Keyworth, Nottingham

MineralsUK
Centre for sustainable mineral development

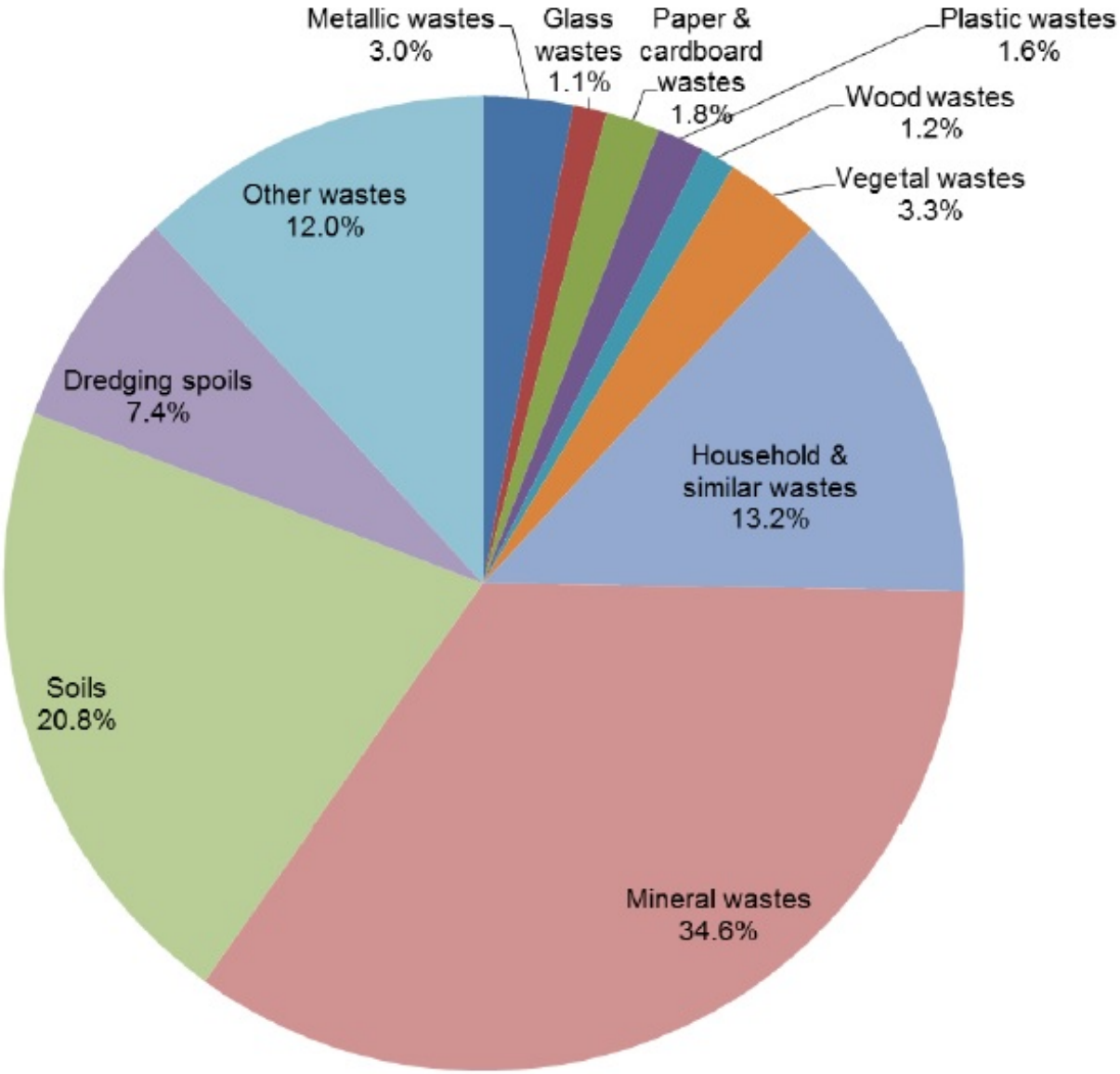
What is mineral waste?

- Mineral waste is anything left over from a mining and quarrying operation that cannot find a productive use
- Large volumes of material of waste are formed of overburden removal, inferior material that does not meet requirements, and oversize material and fines that are produced by processing.
- Much of this waste is used to back fill old pits, create haul roads or bunds, but a lot remains in waste tips or tailings lagoons.
- Waste a poor use of a valuable resource - it can create environmental and safety problems and also can sterilise future resources underneath the tips and lagoons

UK mineral waste in context

- In 2012 the UK disposed of 200 million tonnes of waste of which 35% was mineral waste (69.2 million tonnes)
- UK legislation is largely concerned with safety of waste tips and their environmental impact, little concerning its potential as a resource.
- The Landfill Tax & Aggregate Levy were introduced to minimise waste disposal by reducing primary production and encouraging the use of recycled & secondary material as construction aggregate
- Mining & quarrying waste is exempt from UK Landfill Tax - if the lower rate of £2.60 per tonne were applied it would cost £180 million a year !

Figure 5.2: Waste generation split by waste material, UK 2012



UK Statistics on Waste
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487916/UK_Statistics_on_Waste_statistical_notice_15_12_2015_update_f2.pdf

UK Mineral Waste 2014, estimated

Mineral Product	Production	Mineral Waste
	Million tonnes	Million tonnes
Limestone & dolomite	65.5	7.3
Sand & gravel	62.2	15.6
Igneous rock	44.0	4.9
Sandstone	12.5	4.2
Coal	11.5	5.8
Rock Salt & Potash	7.5	0.8
Clay & shale	7.5	7.5
Silica sand	4.0	0.4
Chalk	3.8	0.4
Kaolin, ball clay, fireclay & talc	1.9	17.1
Gypsum	1.2	0.3
Slate	1.0	20.0
Fluorspar, barytes & lead	0.1	0.0
Total	222.7	84.3

Source of production data: UK Minerals Yearbook 2014
http://www.bgs.ac.uk/mineralsuk/statistics/ukStatistics.html

Focus on fines

- Focus of UK mineral waste research has been on fine-grained waste (“quarry fines”) which is seen as the biggest problem
- Quarry fines are typically defined as material finer than 4mm, often referred to as ‘dust’ or ‘fines’, signposted as 0/4mm
- British Standards refer to:
  - BS EN Fine aggregate - <4mm (<2mm for asphalt)
  - BS EN Fines - inherent material <0.063mm
  - BS EN Filler - material <0.063mm added to products

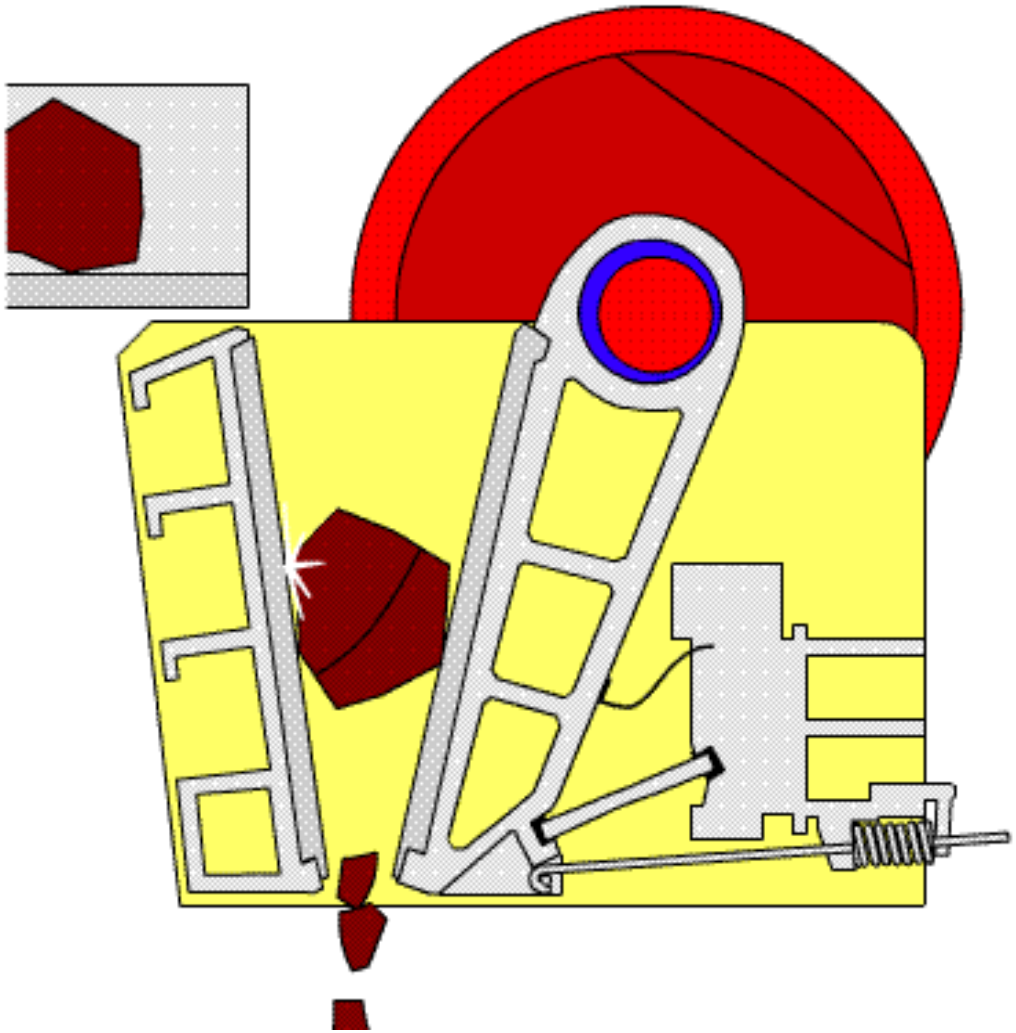
Quarry fines stockpile, Gritstone Quarry

How are fines formed?

- **Extraction** - drilling & blasting, haulage/ transfer
- **Primary crushing** - scalping pre- or post-crushing, primary surge pile
- **Secondary crushing (& further stages)** – cone & impact
- **Screening** - production of aggregate products including quarry fines, recirculation/ recrushing of oversize & coarse aggregate
- **Stockpiling** - uncovered or covered
- **Handling/ distribution/ transportation**
- **Fines/ dust management**

Working benches, Gritstone Quarry

Primary crusher (Gyratory), Granite Quarry



Jaw Crusher

http://www.aggdesigns.com/Jaw-Crusher-info.htm

Primary surgepile, Limestone Quarry

Process plant, Gritstone quarry

Quarry fines stockpile, Gritstone Quarry

Research outcomes

- Four BGS quarry fines research projects (1998-2007)
- Initial findings revealed that the volume and nature of waste produced is largely unknown
- BGS focused on characterisation of the chemical & mineralogical composition and particle-size distribution of quarry fines
- Quarry Fines Minimisation is a means of optimising production - even if only 1-2 % efficiency it increases saleable product and reduces the amount of waste produced
- Artificial Soil - a promising application where quarry fines are mixed with green waste – this represents a simple, high volume solution

BARRASFORD QUARRY (Tarmac Quarry Products North West)

Location: Barrasford Quarry, Barrasford, Hexham, Northumberland, UK

Sample type: Plant fines **Rock type:** Dolerite (Whin Sill, Carboniferous)

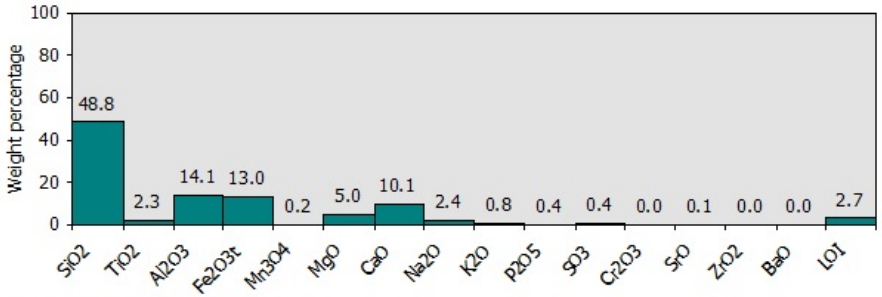
Sampling: Spot sampling **Sample code:** BBF1 / CJM542 **Date:** 1/12/98

Mineralogy

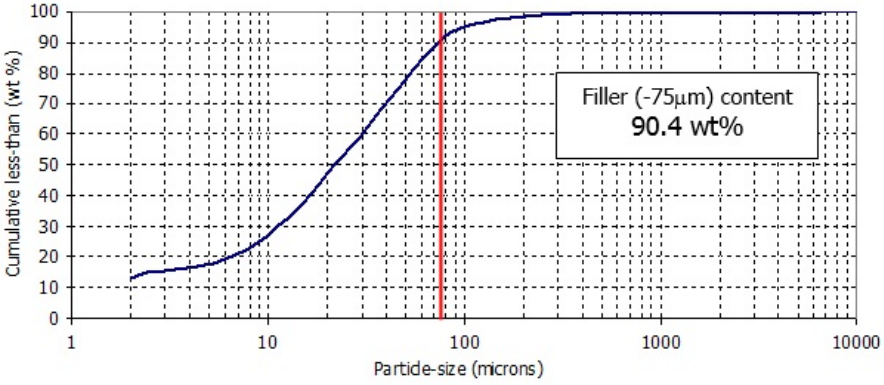
Dominant	Plagioclase feldspar
Major	Augite
Minor	Quartz and ilmenite
Trace	Mica, kaolinite and ?rutile (TiO_2).

Dominant = >50 wt%; Major = 20-50 wt%; Minor = 7-20 wt%; Trace = <7 wt%

Chemistry



Particle-size distribution



CAULDON LOW QUARRY (Tarmac Quarry Products West Midlands)

Location: Cauldon Low Quarry, PO Box 1, Stoke-on-Trent, Staffordshire, UK

Sample type: Filler fines **Rock type:** Limestone (Milldale Limestone, Carboniferous)

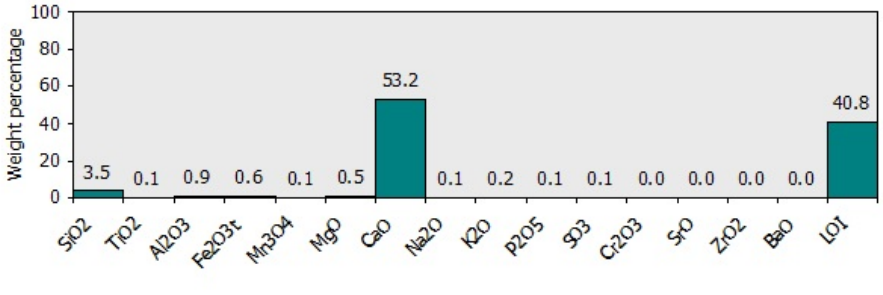
Sampling: Unknown **Sample code:** BCLF1 / F230 **Date:** 16/9/1999

Mineralogy

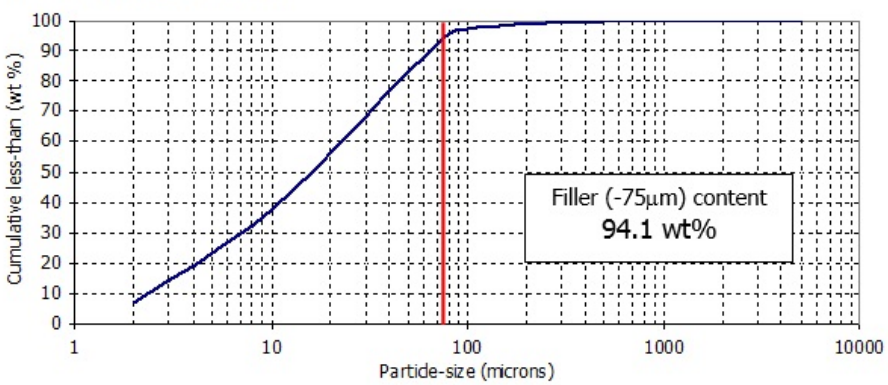
Dominant	Calcite
Major	
Minor	
Trace	Quartz

Dominant = >50 wt%; Major = 20-50 wt%; Minor = 7-20 wt%; Trace = <7 wt%

Chemistry

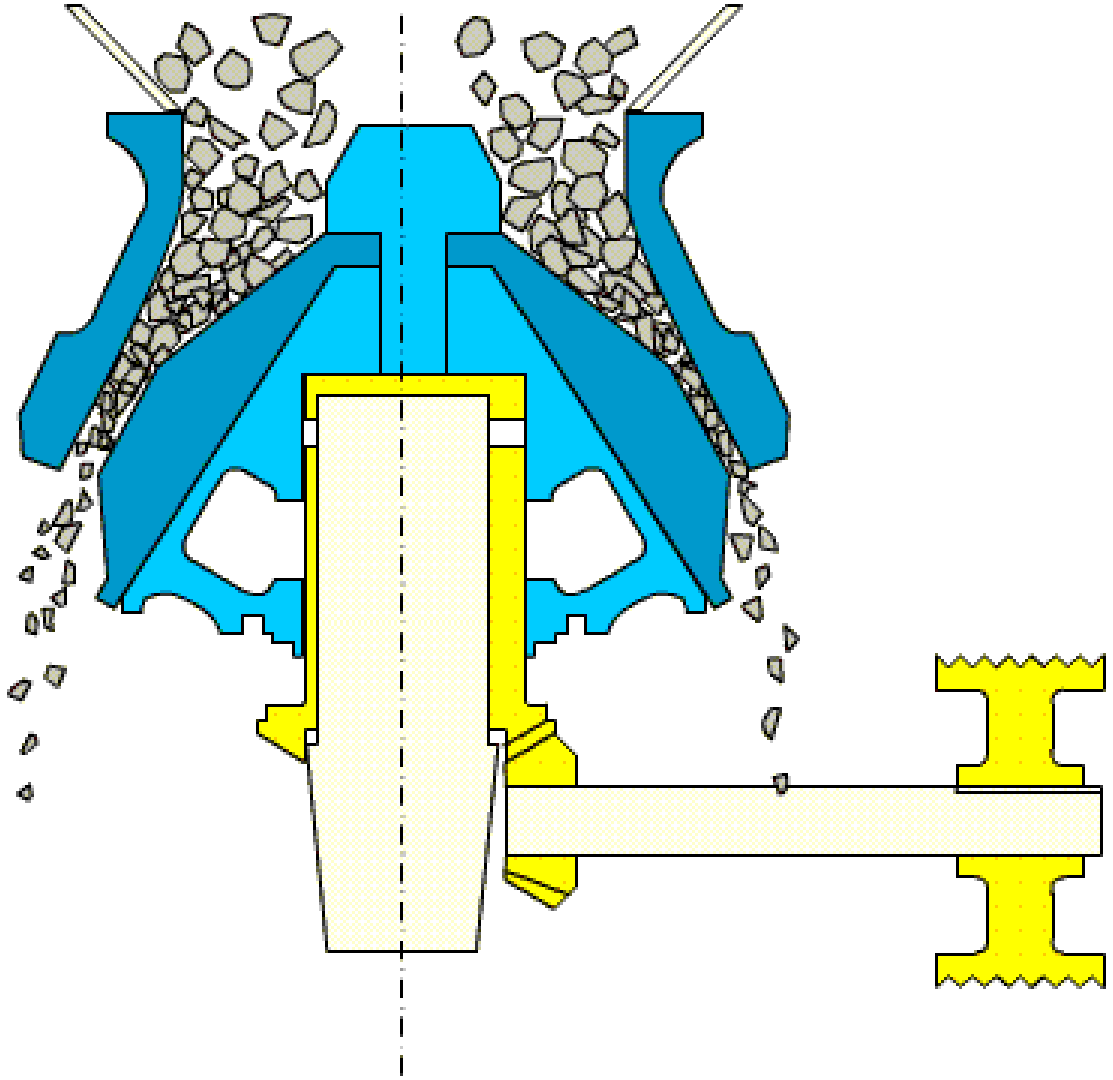


Particle-size distribution



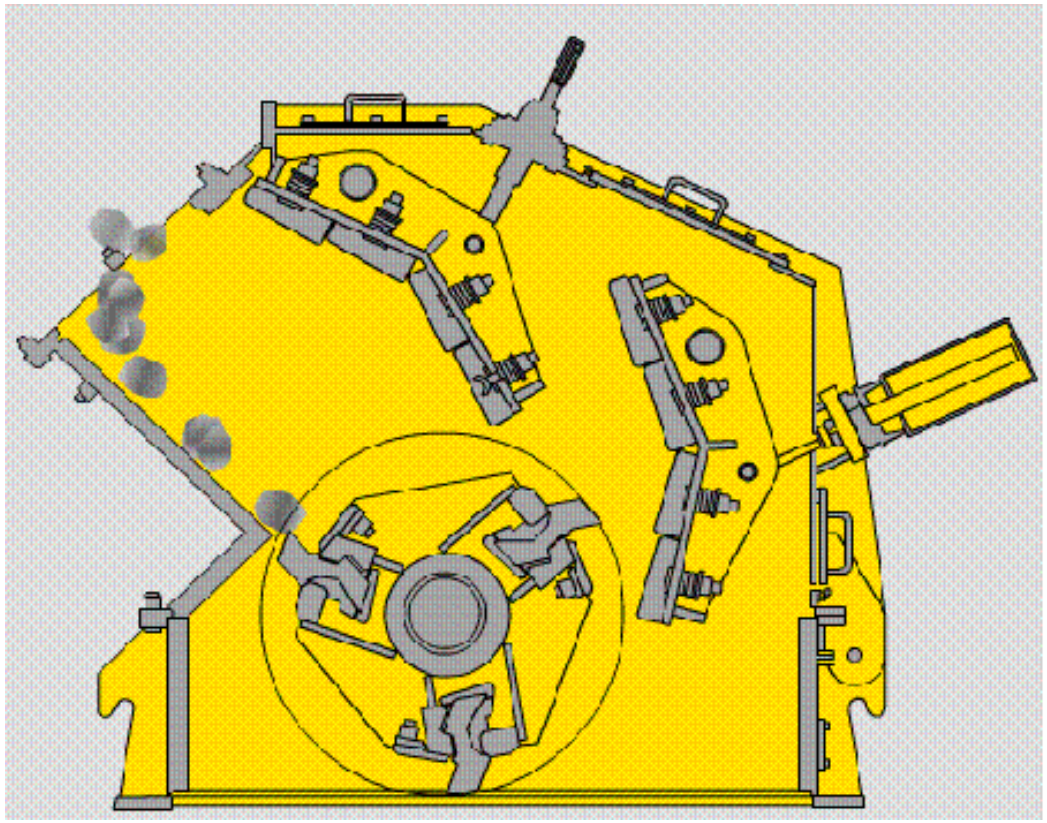
Good Practice for crushers

- **Cone crushers**
  - Evenly distributed choke feeding
  - Optimum size reduction ration of 6:1
  - Optimum speed, high speed = better quality but more fines
- **Impact crushers**
  - Uniform feed to ensure full utilisation of rotor width
  - Optimum rotor speed, greater speed = more fines
  - Pre-screening between crusher stages
  - Open discharge to reduce retention times and minimise fines



Cone Crusher

http://www.aggdesigns.com/Cone-Crusher-info.htm



Impact Crusher

http://www.ami-crushers.com/stock-equipment/impact-crushers/

Growing trial plot, Seisdon quarry, Tarmac

Conclusions

- Mineral waste is a significant national issue
- Understanding the scale of the problem as well as the nature of the waste is a key to unlocking potential solutions
- Waste minimisation is possible by careful consideration and optimisation of the processing plants
- Utilisation of mineral waste in commercial products is possible by exploring the potential markets

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Thank you for your attention!

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